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Aggregation Pheromone in *Orchesella cincta* (Collembola)

BY

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INTRODUCTION

Collembola on a substrate are mostly not distributed at random. On the contrary they seem to concentrate at some preferred microhabitats. Some of the parameters quantifying a microhabitat determine an organism's settling at such a location. Optimum values for each parameter are preferred by the organisms and result in a concentration of individuals in the corresponding optimal area as Joosse (1971) proved for *Orchesella cincta*. « Water, alone or in conjunction with temperature, is probably the most important physical factor affecting the ecology of terrestrial organisms » (Krebs, 1972). In earlier communications (Mertens, Bourgoignie, 1975, 1977) it was concluded that clustering of *Hypogastrura* is caused by intraspecific attraction of individuals in a population. We intend to show that such a phenomenon, caused by an aggregation pheromone, also occurs in *Orchesella cincta* and that clustering in this species is not the only result of the reaction to environmental factors.

I. — MATERIALS AND METHODS

As the experimental procedures are the same as described in earlier papers (*op. cit.* 1975, 1977), only the different experiments will be enumerated here.

1. Locomotory Activity in Activity Boxes.

In the upper compartment of an activity box, originally containing one organism, the decrease in population is given by

$$-\frac{dN}{dt} = \lambda N$$

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With more organisms to begin with (16) in the upper compartment, the slope λ of the resulting function will decrease if aggregation occurs.

2. *Aggregation Response to Impregnated Filter Paper (Two-Choice Method).*

A single animal is introduced in each petri dish. The presence on the impregnated sector is recorded at 25 min. intervals over a period of 450 min. The direct impregnation test is replicated 72 times.

3. *Activity on Filter Paper with Water Flow.*

Only females are used in the test box.

II. — RESULTS AND DISCUSSION

1. Locomotory Activity in Activity Boxes.

In the case of a single specimen in each activity box (N_1 in Tab. I and Fig. 1) an exponential decrease of the population is found. With the same

TAB. I

Numerical values of the decrease of the population

t (30 min.)	N_1	N_{16}
2	1.00	16.00
3	0.98	16.00
4	0.97	16.00
5	0.93	16.00
6	0.89	16.00
7	0.88	15.86
8	0.81	15.57
9	0.78	15.14
10	0.77	15.14
11	0.74	15.14
12	0.72	15.14
13	0.69	14.86
14	0.69	14.86
15	0.67	14.86
16	0.65	14.57
17	0.65	14.00

symbols as previously used, the numerical values in the logarithmic expression of the decrease

$$\ln C = \ln C_o - \lambda\ (t\text{-}t_o)$$

are given by

$$\lambda = 0{,}031 \text{ (corr. coeff. } 0.98)$$

and

$$\ln C_o = -0.001 \text{ (corr. coeff. } 0.98)$$

In the case considered we notice that $\ln C_o = \ln N_{1,0} \simeq 0$ ($N_{1,0} = 1$). This implies that the element contributing to restlessness, as defined for *Hypogastrura* by

$$\ln\mu = Ae^{-\alpha\,(t-t_0)}$$

now becomes $\ln\mu = 0$ with $\mu_{max} = \mu_o = 0$

The function is reduced to

$$\ln N_1 = \ln C_o - \lambda\,(t-t_o) \qquad (1)$$

Integrating the differential equation

$$-\frac{dN_1}{dt} = \lambda N_1 \qquad (2)$$

from t_o to t we find

$$N_1 = N_{1;0}e^{-\lambda\,(t-t_0)}$$

or

$$\ln N_1 = \ln N_{1;0} - \lambda\,(t-t^o)$$

Identification of (1) and (2) leads to

$$\ln C^o = \ln N_{1;0} = 0$$

This means that the activity, the coefficient of N_1 in (2) is reduced to the basic activity λ, constant in time.

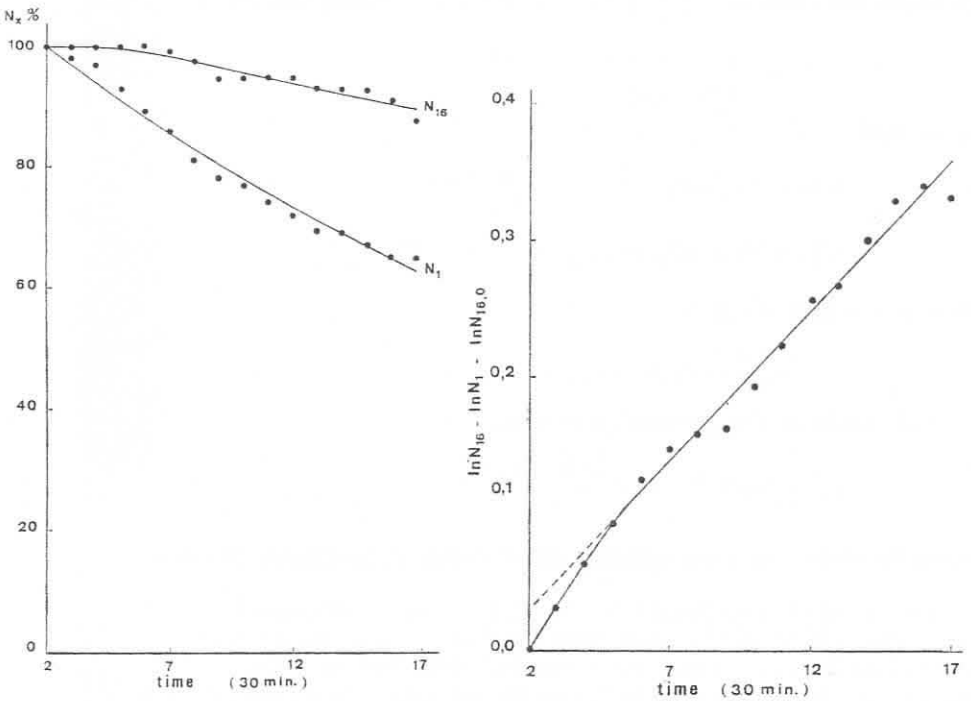

FIG. 1. — (on the left) The percentual decrease of the population as a function of time. The dots are obtained by experiment. The fitted lines are derived from theory.

FIG. 2. — (on the right) Semilogarithmic plot of the influence of aggregation on the activity.

In the case of more animals in each activity box (N_{16} in Tab. I and Fig. 1) it was assumed that the basic activity is not influenced if there is no aggregation and that the decrease in activity is due to aggregation only. To express the decrease of activity caused by clustering, we again set up the function $\ln N_x - \ln N_{x,o} - \ln N_1$. Figure 2 shows that the function is the difference between

$$\ln D = \ln D_o + \gamma\ (t\text{-}t_o)$$

and

$$\ln D' = e^{-\beta\ (t\text{-}t_o)} \ln D_o$$

so that

$$\ln N_x\text{-}\ln N_{x,o}\text{-}\ln N_1 = \gamma\ (t\text{-}t_o)\text{-}\ln D_o\ (e^{-\beta\ (t\text{-}t_o)}\text{-}1) \qquad (4)$$

with the parameters

$$\gamma = 0.022 \text{ (corr. coeff. } 0.97)$$
$$\ln D_o = 0.027 \text{ (corr. coeff. } 0.97)$$
$$\beta = 0.549 \text{ (corr. coeff. } 0.98)$$

The same assumption is made here as in the case of *Hypogastrura* If aggregation does not occur, the basic activity λ cannot decrease by the constant γ and $\ln N_x - \ln N_{x,o} - \ln N_1$ coincides with the abscis. Moreover, the value of γ increases with a factor β for $t < 6$ so that in the range t_o, t_6 the basic activity decreases by $\gamma + \beta$. With $\mu = 0$, the differential equation, as used for *Hypogastrura*, becomes $-\frac{dN_x}{dt} = (\rho + \nu)\, N_x$ ρ and ν being defined as

$$\rho = \lambda - \nu_{min} = ctc$$
$$\nu = \nu_{max} e^{-\beta t}$$

Integrating we find

$$\ln N_x = \ln N_{x,o}\text{-}\rho\ (t\text{-}t_o) + \frac{\nu_{max}}{\beta}\,(e^{-\beta t}\text{-}e^{-\beta t_o}) \qquad (5)$$

$$\ln N_x\text{-}\ln N_{x,o}\text{-}\ln N_1 = \nu_{min}\ (t\text{-}t_o) + \frac{\nu_{max}}{\beta}\,(e^{-\beta t}\text{-}e^{-\beta t_o}) \qquad (6)$$

Identification of (4) and (6) gives :

$$\nu_{min} = \gamma$$
$$\nu_{max} = -\beta e^{\beta t_o} \ln D_o = -0{,}044$$

Summarising (5) leads to the general expression

$$N_x = N_{x,o} e^{-\rho\ (t\text{-}t_o)}\, e^{\frac{\nu_{max}}{\beta}\,(e^{-\beta t}\text{-}e^{-\beta t_o})}$$

2. **Aggregation Response to Impregnated Filter Paper (Two-Choice Method).**

The results are shown in figures 3. As in the case of *Hypogastrura* the impregnated sector (10 % of the total area) causes an aggregation response. The dotted line would correspond to a random distribution. The findings indicate that aggregation, as proved in 1, can be explained not by the physical contact of the organisms only, but also by an induced chemical stimulus at the least.

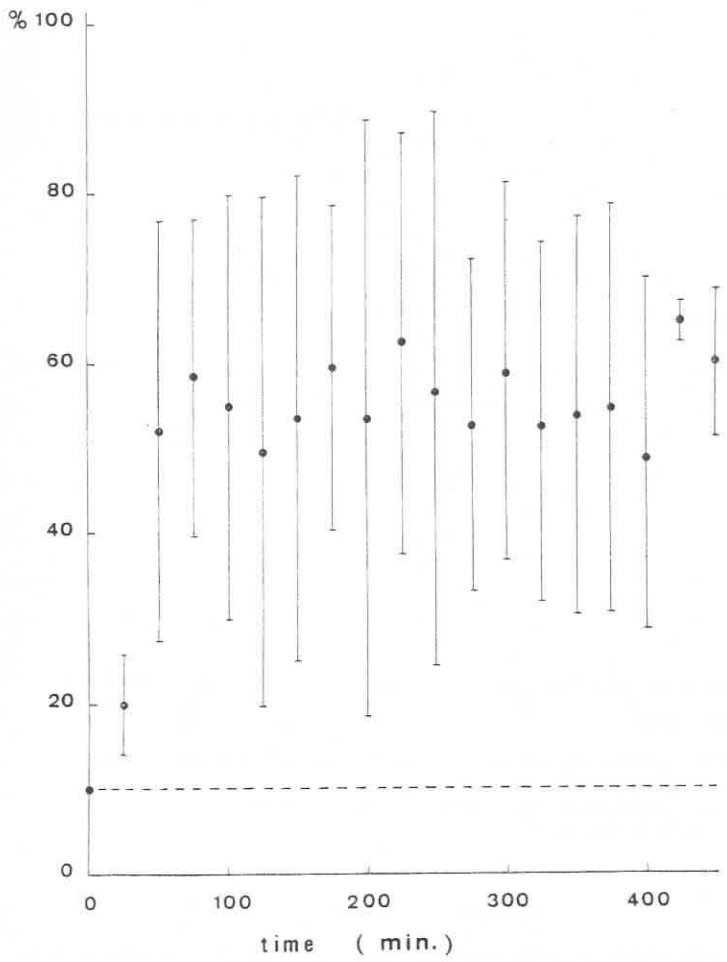

FIG. 3. — Aggregation response to impregnated filter paper.

3. **Activity on Filter Paper with Water Flow.**

The results, illustrated in figures 4 and 5, confirm the findings already mentioned. Here again the decrease in activity can be interpreted as the change in behaviour (locomotory activity to immobility) due to a stimulus perceived with the aggregated animals in box A. The experimental data thus lead to the conclusion that besides exteroreceptive stimuli such as temperature, humidity (JOOSSE, 1971) and pH (MERTENS, 1975) of a microhabitat, chemocommunication also plays an important role in the aggregation of *Orchesella*. On the basis of the available evidence, the particular chemical signals considered here are aggregation pheromones, just as previously proved in the case of *Hypogastrura* (MERTENS, BOURGOIGNIE, 1975, 1977).

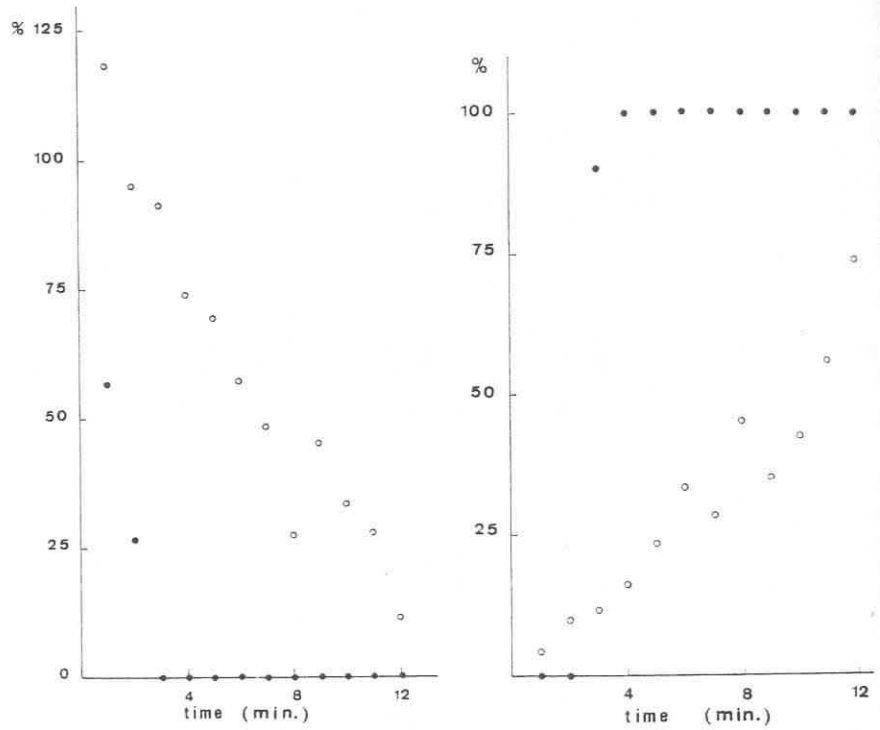

FIG. 4. — (on the left) Locomotory activity on filter paper with water flow. ● : springtails in box A; ○ : no springtails in box A.

FIG. 5. — (on the right) Inactivity on filter paper with waterflow. ● : springtails in box A; ○ : no springtails in box A.

SUMMARY

Analysis of the locomotory activity leads to the conclusion that chemocommunication plays an active role in the aggregation behaviour of *Orchesella cincta*. As previously demonstrated for *Hypogastrura viatica*, the particular chemical stimulus is also an aggregation pheromone.

RÉSUMÉ

Phéromone d'aggrégation chez *Orchesella cincta*

L'analyse de l'activité locomotrice d'*Orchesella cincta* démontre que le comportement d'aggrégation chez cette espèce est contrôlée par un facteur chimique de communication. Comme il a été démontré auparavant pour *Hypogastrura viatica*, le stimulus chimique qui intervient ici, est aussi un phéromone d'aggrégation.

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